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DESCRIPTION

TELESCOPIC SHAFT FOR VEHICLE STEERING

TECHNICAL FIELD

The present invention relates to a telescopic shaft for vehicle steering.

BACKGROUND ART

Conventionally, a steering mechanism of a vehicle employs as its part a telescopic shaft which is constituted by a male shaft and a female shaft brought into spline fitting in order to absorb a displacement in the axial direction created upon running of the vehicle so as not to transmit the displacement or a vibration to a steering wheel. The telescopic shaft is required to reduce a backlash noise in a spline portion, to decrease backlash on the steering wheel, and to reduce a sliding resistance in a sliding movement in the axial direction.

For these reasons, a nylon film is coated on the spline portion of the male shaft of the telescopic shaft and, furthermore, grease is applied on the slide portion, thereby absorbing or mitigating

metallic noise, metallic drumming sound, or the like, and at the same time, reducing the sliding resistance and backlash in the direction of rotation. In this case, the formation process of the nylon film includes cleaning of the shaft, application of a primer, heating of the same, coating of nylon powder, rough cutting, finishing cutting and selective fitting with the female shaft, in this order. The final cutting step is performed by selecting a die in accordance with the precision of the female shaft which has been already processed.

Japanese Patent Application Laid-Open No. 2001-50293 discloses a telescopic shaft for vehicle steering in which balls are provided in grooves formed on the outer periphery of an inner shaft and on the inner periphery of an outer shaft through an elastic member interposed between the groove on the inner shat and the balls. The balls are rotated in an axial movement to decrease a sliding load between the male shaft and the female shaft and, the balls are restricted in rotation so as to transmit torque. This Application further discloses an arrangement that a male groove and a female groove each having a combined section with a certain play are provided on the inner shaft and the outer shaft in order to transmit torque even when the balls are broken.

However, in the former case, it is required to

also suppress backlash to the minimum while suppressing the sliding load of the telescopic shaft to the minimum, so that it is unavoidable to select dies having slightly different over-pin sizes each by several microns to meet the size of the female shaft in the final cutting work for the processing, which results in sharp increase in the manufacturing cost. In addition, the nylon film is abraded with a lapse of time of use to create more backlash in the direction or rotation.

Under the condition of a high temperature inside the engine room, the nylon film is changed in volume and the sliding resistance is conspicuously increased or the abrasion thereof is rapidly advanced, thereby increasing backlash in the direction of rotation. As a result, there is a demand to provide a structure, in a telescopic shaft to be used as a shaft for vehicle steering, which can suppress generation of abnormal sound and deterioration of the steering operability caused by backlash in the direction of rotation for a long time easily and at a low cost.

Also, the telescopic shaft for vehicle steering which is disclosed in the latter Patent Application Laid-Open No. 2001-50293 performs a collapsing operation and torque transmission by means of rolling of a plurality of balls in a normal use. To this end,

it is structurally required to provide an enough number of balls for enduring an input torque. Further, a guide rail or a sleeve which is to be in contact with the balls has to have sufficiently high rigidity for enduring the torque transmission, which is very disadvantageous in terms of the processing performance with a resultant increase of the cost. There are another structural drawbacks that this shaft is difficult be made compact as a telescopic shaft for vehicle steering and also is difficult to have an enough collapse stroke in a vehicle collision. Further, this shaft displays an undesirable feature as a telescopic shaft for vehicle steering that since the arrangement is constituted only by the balls, the sliding load fluctuates.

DISCLOSURE OF THE INVENTION

The present invention has been contrived taking the circumstance as described above into consideration, and an object thereof is to provide a telescopic shaft for vehicle steering which is capable of obtaining a stable sliding load, and of securely preventing backlash in the direction of rotation to transmit torque in a state of high rigidity.

In order to achieve the above object, according to the present invention, there is provided a

telescopic shaft for vehicle steering which is assembled in a steering shaft of a vehicle and in which a male shaft and a female shaft are fitted to each other to be unrotatable and slidable, comprising:

torque transmitting portions respectively provided in an outer peripheral portion of the male shaft and in an inner peripheral portion of the female shaft for transmitting torque when they are mutually in contact to rotate; and

preloading portion each consisting of a rolling member provided between the outer peripheral portion of the male shaft and the inner peripheral portion of the female shaft at a position different from that of the torque transmitting portion for rotating when the male shaft and the female shaft are relatively moved in the axial direction and an elastic member provided adjacently to the rolling member in the radial direction for applying preload on the male shaft and the female shaft through the rolling member.

Also, it is preferable, in the telescopic shaft for vehicle steering according to the present invention, that the torque transmitting portions are always in contact to each other.

Also, it is preferable, in the telescopic shaft for vehicle steering according to the present invention, that each of the torque transmitting portions is

comprised of an axial protrusion formed on the outer peripheral surface of the male shaft to have a substantially arcuate cross section and an axial groove formed on the inner peripheral surface of the female shaft to have a substantially arcuate cross section.

Also, it is preferable, in the telescopic shaft for vehicle steering according to the present invention, that the torque transmitting portions are contacted to each other continuously in the axial direction.

Also, it is preferable, in the telescopic shaft for vehicle steering according to the present invention, that the torque transmitting portions comprise spline fitting portions or serration fitting portions formed on the outer peripheral surface of the male shaft and on the inner peripheral surface of the female shaft.

Also, it is preferable, in the telescopic shaft for vehicle steering according to the present invention, that:

each of the preloading portions comprises a first axial groove provided on the outer peripheral surface of the male shaft and a second axial groove provided on the inner peripheral surface of the female shaft to be opposite to the first axial groove; and

the rolling member and the elastic member are provided between the first and second axial grooves.

Also, it is preferable, in the telescopic shaft for vehicle steering according to the present invention, that a plurality of the preloading portions are provided between the male shaft and the female shaft, and a plurality of the torque transmitting portions are provided between two adjacent ones of the preloading portions.

Also, it is preferable, in the telescopic shaft for vehicle steering according to the present invention, that the preloading portions are provided at intervals of 180° in the circumferential direction and each of the torque transmitting portions is provided between the preloading portions.

Also, it is preferable, in the telescopic shaft for vehicle steering according to the present invention, that the preloading portions are provided at intervals of 120° in the circumferential direction and each of the torque transmitting portions is provided between the preloading portions.

Also, it is preferable, in the telescopic shaft for vehicle steering according to the present invention, that the torque transmitting portions are provided at a central portion in the circumferential direction between the preloading portions.

Also, it is preferable, in the telescopic shaft

for vehicle steering according to the present invention, that the rolling member comprises at least one spherical member.

Also, it is preferable, in the telescopic shaft for vehicle steering according to the present invention, that the elastic member comprises a leaf spring.

Also, it is preferable, in the telescopic shaft for vehicle steering according to the present invention, that a solid lubricant film is formed in the outer peripheral portion of the male shaft or in the inner peripheral portion of the female shaft.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side view of a steering mechanism of a vehicle to which a telescopic shaft for vehicle steering according to an embodiment of the present invention is applied;

Fig. 2 is a cross-sectional view of the telescopic shaft for vehicle steering according to a first embodiment of the present invention, taken along the center line in the axial direction thereof;

Fig. 3 is a cross-sectional view taken along the line X-X in Fig. 1;

Fig. 4 is a graph for showing a relationship between a stroke and a sliding load of the telescopic shaft for vehicle steering according to the first

embodiment;

Fig. 5 is a cross-sectional view of the telescopic shaft for vehicle steering according to a second embodiment of the present invention, taken along the center line in the axial direction thereof,

Fig. 6 is a cross-sectional view taken along the line X-X in Fig. 4;

Fig. 7 is a cross-sectional view of the telescopic shaft for vehicle steering according to a third embodiment of the present invention, taken along the center line in the axial direction thereof,

Fig. 8 is a cross-sectional view taken along the line X-X in Fig. 6;

Fig. 9 is a transversal cross-sectional view of the telescopic shaft for vehicle steering according to a fourth embodiment of the present invention;

Figs. 10A, 10B and 10C are transversal cross-sectional views of a telescopic shaft for vehicle steering according to first, second and third examples of a fifth embodiment of the present invention, respectively;

Figs. 11A, 11B and 11C are transversal cross-sectional views of a telescopic shaft for vehicle steering according to first, second and third examples of a sixth embodiment of the present invention, respectively; and

Figs. 12A, 12B and 12C are transversal cross-

sectional views of a telescopic shaft for vehicle steering according to first, second and third examples of a seventh embodiment of the present invention, respectively.

EMBODIMENTS OF THE INVENTION

A telescopic shaft for vehicle steering according to an embodiment of the present invention will be described below with reference to drawings.

Fig. 1 is a side view of a steering mechanism of a vehicle to which a telescopic shaft for vehicle steering according to an embodiment of the present invention is applied.

Referring to Fig. 1, a steering mechanism is comprised of an upper steering shaft portion 120 (including a steering column 103 and a steering shaft 104 which is rotatably held by the steering column) which is attached to a body-side member 100 through an upper bracket 101 and a lower bracket 102, a steering wheel 105 which is attached to the upper end of the steering shaft 104, a lower steering shaft portion 107 which is coupled to the lower end of the steering shaft 104 through a universal joint 106, a pinion shaft 109 which is coupled to the lower steering shaft portion 107 through a steering shaft joint 108, and a steering rack 112 which is coupled to the pinion shaft 109 and is fixed to another frame

110 of the vehicle body through an elastic member 111.

Here, the upper steering shaft portion 120 and the lower steering shaft portion 107 respectively employ a telescopic shaft for vehicle steering according to an embodiment of the present invention (hereinafter called the telescopic shaft). The lower steering shaft portion 107 is comprised of a male shaft and a female shaft fitted to each other. Such a lower steering shaft portion 107 is required to have the capacity of absorbing a displacement in the axial direction which is generated upon running of the vehicle so as to prevent such a displacement or a vibration from propagating onto the steering wheel 105. Such a capacity is required for a structure in which the vehicle body has a sub-frame structure, in which the member 100 for fixing an upper part of the steering mechanism and the frame 110 to which the steering rack 112 are secured are separately arranged, and the member 100 and the frame 110 are connected and fixed to each other through the elastic member 111 such as rubber. There are another cases in which a length changing function is required for an operator to temporarily reduce the telescopic shaft so as to fit and connect the telescopic shaft to the pinion shaft 109 when connecting the steering shaft joint 108 to the pinion shaft 109. Further, the upper steering shaft portion 120 which is provided in

an upper part of the steering mechanism is also constituted by a male shaft and a female shaft fitted to each other. Such an upper steering shaft 120 is required to have the function of expanding and contracting in the axial direction because it is required to have the function of moving the position of the steering wheel 105 in the axial direction to thereby adjust this position in order to obtain an optimal position for the driver to drive the vehicle. In all of the cases described above, the telescopic shaft is required to decrease the rattling sound in the fitting portions, to suppress clatters on the steering wheel 105, and to reduce a sliding resistance in a sliding movement in the axial direction.

(First Embodiment)

Fig. 2 is a cross-sectional view of a telescopic shaft for vehicle steering according to a first embodiment of the present invention, taken along the center line in the axial direction thereof, Fig. 3 is a cross-sectional view taken along the line X-X in Fig. 2, and Fig. 4 is a graph for showing a relationship between a stroke and a sliding load of the telescopic shaft for vehicle steering according to the first embodiment.

As shown in Figs. 2 and 3, the telescopic shaft for vehicle steering (hereinafter called the

telescopic shaft) is comprised of a male shaft 1 and a female shaft 2 which are mutually fitted to be unrotatable and slidable.

In the first embodiment, on the outer peripheral surface of the male shaft 1, there are formed three protrusions 4 extended in the axial direction at intervals of 120° in the circumferential direction, each having a substantially arcuate cross section. To be corresponding thereto, three grooves 6 extended in the axial direction each having a substantially arcuate cross section are also formed on the inner peripheral surface of the female shaft 2 at the positions opposed to three axial protrusions 4 of the male shaft 1. The axial protrusions 4 and the axial grooves 6 are brought into mutual contact to form torque transmitting portions.

On the outer peripheral portion of the male shaft 1, first grooves 3 extended in the axial direction (hereinafter called the axial grooves 3) each having a substantially U shape are formed between adjacent ones of the three axial protrusions 4. On the inner peripheral surface of the female shaft 2, three second grooves 5 extended in the axial direction (hereinafter called the axial grooves 5) each having a substantially arcuate cross section are formed to oppose to the axial grooves 3 of the male shaft 1. Rolling members 7 are interposed between

the axial groove 3 of the male shaft 1 and the axial groove 5 of the female shaft 2 through a wave-shaped elastic member 8 for preloading. The rolling members 7 are arranged to rotate when the male shaft 1 and the female shaft 2 are relatively moved in the axial direction, and to be restrained by the elastic member 8 in rotation to generate no backlash.

Flat portions 8a, 8a on the both sides of the elastic members 8 are in pressure contact with wall portions 3a, 3a on the both sides of the axial groove 3, so as to restrain the whole elastic member 8 not to move in the circumferential direction. The elastic member 8 is arranged to apply preload onto the rolling members 7 and, at the same time, to preload the rolling members 7 and the axial protrusions 4 to the extent that they have no backlash with respect to the female shaft 2.

At an end portion into which the male shaft 1 is inserted in the female shaft 2, a stopper plate 9 for latching the elastic member 8 to fix it in the axial direction is caulked to the male shaft 1 by the use of a caulking portion 10. This stopper plate 9 also works to prevent the rolling members 7 from deviating from the axial groove 3. Thus, there is formed the telescopic shaft for vehicle steering according to the first embodiment.

Since the telescopic shaft of the first

embodiment has such a structure, the male shaft 1 and the female shaft 2 are always in contact to be slidable in each torque transmitting portion by the presence of a preloading portion. As a result, the male shaft 1 and the female shaft 2 are mutually slid when they are relatively moved in the axial direction and the rolling members 7 can rotate.

Fig. 4 is a graph for showing a relationship between a stroke and a sliding load of the telescopic shaft for vehicle steering according to the first embodiment. In Fig. 4, a relationship between a stroke and a sliding load by the use of a ball rolling only, that in case of a sliding only, and that in case of the present invention are compared with each other. From this graph, it is seen that the telescopic shaft for vehicle steering according to the present embodiment has a low sliding load, is capable of suppressing a fluctuation in sliding load, and has smooth sliding characteristics.

Note that a curvature of the axial protrusion 4 is different from that of the axial groove 6, and the axial protrusions 4 and the axial grooves 6 may be respectively formed in such a manner that they are brought into contact continuously in the axial direction when they are to be brought into contact. Also, the same functions and effects as those in the first embodiment can be obtained even if the axial

protrusions 4 formed on the male shaft are formed on the female shaft side and the axial grooves 6 formed on the female shaft are formed on the male shaft side. It is also possible to arrange such that a curvature of the axial groove 5 is different from that of the rolling member 7 so that the both members can be brought into point contact. Also, the rolling member 7 may take a spherical form. Further, the elastic member 8 may be a leaf spring. It is also possible to obtain a lower sliding load by applying grease on a sliding surface and a rolling surface.

The telescopic shaft of the first embodiment thus constituted is superior in the following points, compared with that of the prior art.

If the sliding surface is caused by pure sliding as in the prior art, a preload for preventing backlash can be fixed only to some extent. That is, since the sliding load is obtained by multiplying a coefficient of friction by a preload, if the preload is raised to prevent backlash or to improve the rigidity of the telescopic shaft, the sliding load is increased. Hence forms a vicious circle.

In this respect, in the present embodiment, the preloading portion employs a rolling mechanism of the rolling members 7 for relative movement in the axial direction, so that the preload can be raised without conspicuous increase of the sliding load. With this

arrangement, it is possible to achieve prevention of backlash and improvement of the rigidity without increasing the sliding load, which can not be achieved by the prior art.

Then, at the time of torque transmission, the axial protrusions 4 of the torque transmitting portion are brought into contact with the axial grooves 6 to perform a task of torque transmission. On the other hand, in the preloading portion, the leaf spring 8 is elastically deformed to restrain the spherical members 7 in the circumferential direction between the male shaft 1 and the female shaft 2, thereby preventing backlash.

For example, when a torque is inputted from the male shaft 1, since the preload of the elastic member 8 is applied in the initial stage, backlash can be prevented.

Further, when the torque is increased, the axial protrusion 4 of the torque transmitting portion is brought into strong contact with a side of the axial groove 6 so that the axial protrusion 4 receives a reaction force more strongly than the spherical member 7, whereby the torque is transmitted mainly by the torque transmitting portion. For this reason, in the first embodiment, it is possible to securely prevent backlash in the direction of rotation of the male shaft 1 and the female shaft 2

and, at the same time, to transmit the torque in a state of high rigidity.

Since the axial protrusions 4, and the axial grooves 6 which are substantially arcuate in cross section, are brought into contact continuously mainly in the axial direction to receive the load thereof, there can be obtained various advantages including that a contact pressure can be suppressed to be lower than the case where the load is supported by point contacts of the rolling member 7. Accordingly, the present invention is superior to the prior art employing the ball rolling structure for all of the rows in the following items.

- The damping effect in the sliding portion is greater, compared with the case of the ball rolling structure. As a result, the vibration absorbing performance is higher.

- If the same torque is to be transmitted, the contact pressure can be suppressed to be lower with the axial protrusions 4, so that the length of the torque transmitting portion in the axial direction can be shortened, whereby the space can be used effectively.

- If the same torque is to be transmitted, the contact pressure can be suppressed to be lower with the axial protrusions 4, so that an additional step for hardening the surfaces of the axial grooves of

the female shaft by thermal treatment or the like is not required.

- The number of the constituent parts can be reduced.
- The assembling performance can be improved.
- The assembling cost can be reduced.
- Since the task of torque transmission is mainly taken by the torque transmitting portion, the number of the rolling members 7 can be reduced and the collapse stroke can be set to be great.

The present invention is, since partially employing the rolling member 7 structure, superior to the prior art employing the structure that all rows are spline fitted and all rows are slidable, in the following items.

- Since a coefficient of friction is low, the sliding load can be suppressed to be low.
- The preload can be set high so that it is simultaneously possible to prevent backlash for a long time and to obtain high rigidity.

(Second Embodiment)

Fig. 5 is a cross-sectional view of the telescopic shaft for vehicle steering according to a second embodiment of the present invention, taken along the center line in the axial direction thereof, and Fig. 6 is a cross-sectional view taken along the line X-X in Fig. 5. The same arrangements as those

in the first embodiment are given the same referential numbers and symbols and the description thereof will be omitted.

The second embodiment of the present invention is different from the first embodiment in that a solid lubricant film 11 is formed on the outer peripheral surface of the male shaft 1. Since a contact resistance between the axial protrusion 4 and the axial groove 6 of the torque transmitting portion can be lowered by thus forming the solid lubricant film 11 on the outer peripheral surface of the male shaft 1, the total sliding load (which is a sliding load generated in a normal use in the structure of the present invention in which both rolling and sliding are in action) can be lower, compared with that of the first embodiment.

Then, also in the second embodiment, the same functions and effects as those in the first embodiment can be obtained.

The solid lubricant film 11 is obtained, for example, by a process in which powder of molybdenum dioxide is dispersed and mixed in resin, a spraying or dipping method is applied and then a baking method is applied, or by a process in which PTFE (poly-tetrafluoro-ethylene) is dispersed and mixed in resin and a spraying or dipping method is applied and then a baking method is applied.

Note that, in the second embodiment, the solid lubricant film 11 is formed along the entire outer peripheral surface of the male shaft 1. However, the solid lubricant film 11 may be provided only on the outer peripheral surfaces of the three axial protrusions 4 which are formed on the male shaft 1. This is because the sliding load is mainly caused by the contact between the axial protrusions 4 and the axial grooves 6 so that the sliding resistance in the axial direction can be reduced by reducing the contact resistance of the contact portions therebetween.

It is also possible to obtain a further lower sliding load by applying grease on the sliding surface and the rolling surface. Also, the curvature of the axial protrusion 4 may be different from that of the axial groove 6 so that the axial protrusions 4 and the axial grooves 6 may be formed in such a manner that they are brought into contact with each other continuously in the axial direction. The same functions and effects as those in the this embodiment can be obtained even if the axial protrusions 4 formed on the male shaft are formed on the female shaft side and the axial grooves 6 formed on the female shaft are formed on the male shaft side. It is also possible to arrange such that a curvature of the axial groove 5 is different from that of the

rolling member 7 so that the both members can be brought into point contact. Also, the rolling member 7 may take a spherical form. Further, the elastic member 8 may be a leaf spring.

(Third Embodiment)

Fig. 7 is a cross-sectional view of the telescopic shaft for vehicle steering according to a third embodiment of the present invention, taken along the center line in the axial direction thereof, and Fig. 8 is a cross-sectional view taken along the line X-X in Fig. 7. The same arrangements as those in the second embodiment are given the same referential numbers and symbols and the description thereof will be omitted.

The third embodiment is different from the second embodiment in that the male shaft 1 is formed to have a hollow structure (a hollow portion 13) in order to reduce the weight of the entire telescopic shaft for vehicle steering and that, with this hollow structure of the male shaft 1, the stopper plate 12 is inserted in the hollow portion 13 of the male shaft 1 and then caulked. Other arrangements, functions and effects are the same as those in the second embodiment, and the description thereof will be omitted.

Note that in the third embodiment, the solid lubricant film 11 is formed along the entire outer

peripheral surface of the male shaft 1. However, the solid lubricant film 11 may be provided only on the outer peripheral surfaces of the three axial protrusions 4 which are formed on the male shaft 1. Note that, the same function and effect can be obtained if the solid lubricant film 11 is formed on the inner peripheral surface side of the female shaft 2.

Also, a curvature of the axial protrusion 4 may be different from that of the axial groove 6, and the axial protrusions 4 and the axial grooves 6 may be respectively formed in such a manner that they are brought into contact continuously in the axial direction when they are brought into contact. Also, the same function and effect as those in the present embodiment can be obtained even if the axial protrusions 4 formed on the male shaft are formed on the female shaft side and the axial grooves 6 formed on the female shaft are formed on the male shaft side. It is also possible to arrange such that a curvature of the axial groove 5 is different from that of the rolling member 7 so that the both members can be brought into point contact. Also, the rolling member 7 may take a spherical form. Further, the elastic member 8 may be a leaf spring. It is also possible to obtain a lower sliding load by applying grease on a sliding surface and a rolling surface.

(Fourth Embodiment)

Fig. 9 is a transversal cross-sectional view of the telescopic shaft for vehicle steering according to a fourth embodiment of the present invention. The same arrangements as those in the first embodiment are given the same referential numbers and symbols and the description thereof will be omitted.

The fourth embodiment is different from the first embodiment in that the solid lubricant film 11 is formed on the inner peripheral surface of the female shaft 2. Since it is possible to lower a contact resistance between the axial protrusion 4 and the axial groove 6 of the torque transmitting portion by thus forming the solid lubricant film 11 on the inner peripheral surface of the female shaft 2, the total sliding load (which is a sliding load generated in a normal use in the structure of the present invention in which both rolling and sliding are in action) can be lower, compared with the case of the first embodiment.

Then, also in the fourth embodiment, the same function and effect as those in the first embodiment can be obtained.

The solid lubricant film 11 is obtained, for example, by a process in which powder of molybdenum dioxide is dispersed and mixed in resin and a spraying or dipping method is applied and then a

baking method is applied, or by a method PTFE (polytetrafluoro-ethylene) is dispersed and mixed in resin and a spraying or dipping method is applied and then a baking method is applied.

Note that, in the fourth embodiment, the solid lubricant film 11 is formed along the entire inner peripheral surface of the female shaft 2. However, the solid lubricant film 11 may be provided only on the inner peripheral surfaces of the three axial grooves 6 which are formed on the female shaft 2. This is because the sliding load is mainly caused by the contact between the axial protrusions 4 and the axial grooves 6 so that the sliding resistance in the axial direction can be reduced by reducing the contact resistance of the contact portions therebetween.

It is also possible to obtain a further lower sliding load by applying grease on the sliding surface and the rolling surface. Also, the curvature of the axial protrusion 4 may be different from that of the axial groove 6 so that the axial protrusions 4 and the axial grooves 6 may be formed in such a manner that they are brought into contact with each other continuously in the axial direction. The same function and effect as those in the this embodiment can be obtained even if the axial protrusions 4 formed on the male shaft are formed on the female

shaft side and the axial grooves 6 formed on the female shaft are formed on the male shaft side. It is also possible to arrange such that a curvature of the axial groove 5 is different from that of the rolling member 7 so that the both members can be brought into point contact. Also, the rolling member 7 may take a spherical form. Further, the elastic member 8 may be a leaf spring.

(Fifth Embodiment)

Figs. 10A, 10B and 10C are transversal cross-sectional views of telescopic shafts for vehicle steering according to first, second and third examples of a fifth embodiment of the present invention, respectively. The same arrangements as those in the first embodiment are given the same referential numbers and symbols and the description thereof will be omitted.

First Example

In a first example shown in Fig. 10A, on the telescopic shaft for vehicle steering consisting of the male shaft 1 and the female shaft 2 brought into spline fitting, there is provided a preloading portion similar to that in the first embodiment at one position between the male shaft 1 and the female shaft 2.

More specifically, as shown in Fig. 10A, the telescopic shaft for vehicle steering (hereinafter

called the telescopic shaft) is comprised of the male shaft 1 and the female shaft 2 which are mutually spline-fitted to be unrotatable and slidable.

In the first example, on the outer peripheral surface of the male shaft 1, there are formed a plurality of protrusions 14 extended in the axial direction for the spline fitting. To be corresponding thereto, a plurality of grooves 16 extended in the axial direction are also formed on the inner peripheral surface of the female shaft 2. The axial protrusions 14 and the axial grooves 16 are brought into spline fitting to constitute a torque transmitting portion.

A first axial groove 3 extended in the axial direction (hereinafter called the axial groove 3) having a substantially U shape is formed at one position on the outer peripheral surface of the male shaft 1, instead of the axial protrusion 14 for spline fitting. To be corresponding thereto, on the inner peripheral surface of the female shaft 2, a second axial groove 5 extended in the axial direction (hereinafter called the axial grooves 5) having a substantially arcuate cross section is formed at a position opposite to the axial groove 3. Rolling members 7 are interposed between the axial groove 3 and the axial groove 5 through a wave-shaped elastic member 8 for preloading. The rolling members 7 are

arranged to rotate when the male shaft 1 and the female shaft 2 are relatively moved in the axial direction, and to be restrained by the elastic member 8 to prevent generation of backlash.

The elastic member 8 is in pressure contact with wall portions 3a, 3a on the both sides of the axial groove 3 at flat portions 8a, 8a on the both sides thereof, so as to restrain the whole elastic member 8 not to move in the circumferential direction. Then, the elastic member 8 acts to apply preload onto the rolling members 7 and, at the same time, onto the rolling members 7 and the axial protrusions 14 to the extent to generate no backlash with respect to the female shaft 2. Thus, there is formed the telescopic shaft for vehicle steering according to the first example.

Since the telescopic shaft of the first example has such a structure, the male shaft 1 and the female shaft 2 are always in contact to be slidable at the respective torque transmitting portions by the presence of the preloading portion. As a result, the male shaft 1 and the female shaft 2 are mutually slid when they are relatively moved in the axial direction and the rolling member 7 rotates.

On the telescopic shaft constituted as described above, the axial protrusion 14 and the axial groove 16 serving as the torque transmitting

portion are spline-fitted to each other between the male shaft 1 and the female shaft 2 and, at the same time, the rolling members 7 are interposed between the axial groove 3 and the axial groove 5 through the elastic member 8 so that the preload is given to the rolling members and the axial protrusions 14 by the elastic member 8 to the extent to generate no backlash with respect to the female shaft 2.

When no torque is transmitted, it is possible to prevent backlash between the male shaft 1 and the female shaft 2 without fail and, at the same time, to slide the male shaft 1 and the female shaft 2 in the axial direction with a stable sliding load without backlash when the male shaft 1 and the female shaft 2 are to be moved relatively to each other in the axial direction.

When a torque is transmitted, a spline-fitting portion between the axial protrusion 14 and the axial groove 16 of the torque transmitting portion functions to mainly perform the task of torque transmission, and the elastic member 8 is elastically deformed in the preloading portion to restrain the spherical member 7 between the male shaft 1 and the female shaft 2 in the circumferential direction, thereby preventing backlash.

Other functions and effects are the same as those in the first embodiment, and the description

thereof will be omitted.

Second Example

In a second example shown in Fig. 10B, on the telescopic shaft for vehicle steering consisting of the male shaft 1 and the female shaft 2 brought into spline fitted thereon, there are provided preloading portions similar to that in the first example at intervals of 180° between the male shaft 1 and the female shaft 2 in the circumferential direction. Then, a plurality of torque transmitting portions similar to that in the first example are respectively provided in the preloading portions.

Since there are provided two preloading portions as described above, the sliding load can be further reduced, compared with that in the first example, and, at the same time, the backlash can be prevented.

Other arrangements, functions and effects are the same as those in the first example, and the description thereof will be omitted.

Third Example

In a third example shown in Fig. 10C, on the telescopic shaft for vehicle steering consisting of the male shaft 1 and the female shaft 2 spline fitted thereon, there are provided preloading portions similar to that in the first example at regular intervals of 120° between the male shaft 1 and the

female shaft 2 in the circumferential direction. Then, a plurality of torque transmitting portions similar to that in the first example are respectively provided in the preloading portions.

Since there are provided three preloading portions in the circumferential direction as described above, the sliding load can be further reduced, compared with that in the first and second examples, and, at the same time, the backlash can be prevented. Also, since the preloading portions are provided in the circumferential at an interval of 120°, the eccentricity of the shaft can be reduced so that the uneven presence of the sliding load can be improved. Other arrangements, functions and effects are the same as those in the first and second examples, and the description thereof will be omitted.

Note that in the first to third examples described above, a further lower sliding load can be obtained by applying grease on the sliding surface and the rolling surface. Also, the same function and effect as those in the this embodiment can be obtained even if the axial protrusions 14 formed on the male shaft are formed on the female shaft side and the axial grooves 16 formed on the female shaft are formed on the male shaft side. It is also possible to arrange such that a curvature of the axial groove 5 is different from that of the rolling

member 7 so that the both members can be in point contact. Also, the rolling member 7 may take a spherical form. Further, the elastic member 8 may be a leaf spring.

(Sixth Embodiment)

Figs. 11A, 11B and 11C are transversal cross-sectional views of telescopic shafts for vehicle steering according to first, second and third examples of a sixth embodiment of the present invention, respectively. The same arrangements as those in the fifth embodiment are given the same referential numbers and symbols and the description thereof will be omitted.

The sixth embodiment is different from the fifth embodiment in that the solid lubricant film 11 is formed on the outer peripheral surface of the male shaft 1. Since it is possible to lower a contact resistance between the axial protrusion 14 and the axial groove 16 of the torque transmitting portion by thus forming the solid lubricant film 11 on the outer peripheral surface of the male shaft 1, the total sliding load (which is a sliding load generated in a normal use in the structure of the present invention in which both rolling and sliding are in action) can be lower than that of the fifth embodiment. Then, also in the sixth embodiment, the same function and effect as those in the fifth embodiment can be

obtained.

The solid lubricant film 11 is obtained, for example, by a process in which powder of molybdenum dioxide is dispersed and mixed in resin and a spraying or dipping method is applied and then a baking method is applied, or by a process in which PTFE (poly-tetrafluoro-ethylene) is dispersed or mixed in resin and a spraying or dipping method is applied, and then a baking method is applied.

Note that, a further lower sliding load can be obtained by applying grease on the sliding surface and the rolling surface. Also, the same function and effect as those in the this embodiment can be obtained even if the axial protrusions 14 formed on the male shaft are formed on the female shaft side and the axial grooves 16 formed on the female shaft are formed on the male shaft side. It is also possible to arrange such that a curvature of the axial groove 5 is different from that of the rolling member 7 so that the both members can be brought into point contact. Also, the rolling member 7 may take a spherical form. Further, the elastic member 8 may be a leaf spring.

(Seventh Embodiment)

Figs. 12A, 12B and 12C are transversal cross-sectional views of telescopic shafts for vehicle steering according to first, second and third

examples of a seventh embodiment of the present invention, respectively. The same arrangements as those in the fifth and sixth embodiments are given the same referential numbers and symbols and the description thereof will be omitted.

The seventh embodiment is different from the fifth embodiment in that a solid lubricant film 11 is formed on the inner peripheral surface of the female shaft 2. Since it is possible to lower a contact resistance between the axial protrusion 14 and the axial groove 16 of the torque transmitting portion by thus forming the solid lubricant film 11 on the inner peripheral surface of the female shaft 2, the total sliding load (which is a sliding load generated in a normal use in the structure of the present invention in which both rolling and sliding are in action) can be lower than that of the fifth embodiment. Then, also in the seventh embodiment, the same function and effect as those in the fifth embodiment can be obtained.

The solid lubricant film 11 is obtained, for example, by a process in which powder of molybdenum dioxide is dispersed and mixed in resin and a spraying or dipping method is applied and then a baking method is applied, or PTFE (poly-tetrafluoro-ethylene) is dispersed and mixed in resin and a spraying or dipping method is applied, and then a

baking method is applied.

Note that, a further lower sliding load can be obtained by applying grease on the sliding surface and the rolling surface. Also, the same function and effect as those in the this embodiment can be obtained even if the axial protrusions 14 formed on the male shaft are formed on the female shaft side and the axial grooves 16 formed on the female shaft are formed on the male shaft side. It is also possible to arrange such that a curvature of the axial groove 5 is different from that of the rolling member 7 so that the both members can be brought into point contact. Also, the rolling member 7 may take a spherical form. Further, the elastic member 8 may be a leaf spring.

Note that, in the foregoing fourth to sixth embodiments, description is made on the case that the axial protrusions and the axial grooves are for a spline-fitting. However, even if they are for serration-fitting or simply a meshing fitting, the same function and effect can be obtained.

(Other Related Items)

In all of the embodiments of the present invention, a hollow male shaft may be used instead of a solid male shaft, and vice versa.

Also, the following description will be applied in all of the embodiments of the present invention.

It may be arranged such that the tip end of the male shaft is caulked inward to prevent the male shaft from being drawn, so as not to be exploded. The rolling member 7 may be thermally processed and polished. The outer peripheral surface of the male shaft 1 may be coated with resin such as PTFE (poly-tetrafluoro-ethylene)or molybdenum dioxide. A solid or hollow steel member formed by cold drawing may be used as the male shaft 1. An aluminum member formed by cold extrusion may be used as the male shaft 1. A solid steel or aluminum member formed by cold forging may be used as the male shaft 1. A hollow steel member formed by cold drawing may be used as the female shaft 2. It is preferable to subject a material to a metallic soap treatment (bonderization) in order to form the male shaft by cold forging. The female shaft may be formed of a hollow steel tube and may be contracted or expanded after being subjected to a metallic soap treatment (bonderization). Grooves of the female shaft may be formed by pressing. The female shaft may be subjected to nitrogenation. The inner peripheral surface of the female shaft 2 may be coated with resin such as PTFE (poly-tetrafluoro-ethylene) or molybdenum dioxide.

It is preferable that the following numerical ranges are applied in all of the embodiments of the present invention.

- The diameter of a ball serving as the rolling member is around Φ3 to 6mm when the ball is used in a passenger vehicle. A P.C.D. ratio between the ball diameter, and the ball and the axial protrusion is 1 : 3,5 to 5.0 or around.

- The size of the male shaft is not less than 13 mm when an ordinary carbon steel for a machinery structure is used since a twisting strength which is generally required for a passenger vehicle is not less than 250 Nm.

- The contact pressure of the ball is not higher than 1500 MPa in a state that a torque of 100 Nm is applied thereon. The contact pressure of the axial protrusion is not higher than 2000 Mpa in a state that a torque of 100 Nm is applied thereon.

- A ratio between the thickness of the leaf spring serving as the elastic member and the diameter of the ball is 1:10 to 20 or around.

The advantages obtained by the present invention compared with the conventional product are:

low cost;

stable lower slide load;

no backlash;

excellent resistance to wear;

excellent heat fastness;

light-weighted;

smaller mechanism; and

capability of coping with every use conditions without changing the designing concept.

Note that a structure in which preload is applied on axial grooves formed on a male shaft and a female shaft by an elastic member through a plurality of balls is disclosed in Japanese Patent Application Laid-Open No. 2001-50293 and German Patent Publication DE No. 3730393 Al. In this respect, the present invention is conspicuously superior, as described above, to the case that all rows are in a ball rolling structure, or the case that employs a conventional spline fitting.

Also, European Patent Publication No. EP 1078843 Al discloses a structure of preventing backlash by means of a needle roller, a retainer thereof, or a regulator for preventing backlash. However, since this structure employing a pure slip sliding, the preload can not be set great. As a result, it is very difficult to prevent backlash for a long time or to obtain high rigidity.

On the other hand, the present invention can render the following advantageous effects since it partially employs a rolling structure and different means for preventing backlash.

- Since the frictional resistance is low, the sliding load can be reduced.

- The preload can be set high, so that it is

possible to prevent backlash for a long time and to obtain high rigidity simultaneously.

Note that the present invention is not limited to the above-described embodiments, but can be changed in various manners.

As described above, according to the present invention, it is possible to provide a telescopic shaft for vehicle steering which is capable of surely preventing backlash between the male shaft and the female shaft in the direction of rotation so as to transmit torque in a state of high rigidity.